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MEMORANDUM FOR THE RECORD

SUBJECT : Orbit Selection Procedures

1. During many discussions, questions have arisen about the lack of optimum performance of the CORONA system, the reasons for the types of orbits flown, etc. The following discussion is aimed at answering some of the questions. It should be kept in mind that, throughout the CORONA program, a distinct effort was made to keep the system as simple and reliable as possible, operating within the strictest practical security bounds. It is apparent that the system is more complex today than initially, having a more flexible and closer to optimum performance; however, the operation now requires considerably more elaborate techniques and must be operated a bit looser security-wise. I feel that the additional complexity is valid, in giving needed performance, and that the growth process has allowed the introduction of learning, both in the development of operating techniques and in the achieving of adequate reliability.

2. Even now, however, the selection of an operational orbit cannot be based on selection of a single parameter (such as perigee altitude to maximize performance at one particular portion of the orbit). This selection of the operational orbit must be based on the mutual consideration of a large number of factors. At a minimum, the orbit is fully defined by six parameters:

Period
Inclination angle
Eccentricity
Argument of perigee
Right ascension of ascending node
Time of ascending node (including date)

(These parameters, given at one particular time in life of the vehicle, together with the air drag model and earth model, will define the orbit). Other choices of independent variables can be made, but generally six independent variables are at the disposal of the operations section. While these variables are independent, they are constrained by considerations of the launch site and injection trajectory.

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3. The independent variables generally quoted by the contractors are: period, inclination angle, injection or perigee altitude, launch time, and perigee location. While these are independent variables, the practical control system used results in interaction between these. Thus, in error analysis, etc., they cannot be considered as independent. It is apparent from many of the studies that have been made that it is difficult, if not impossible, to generate a set of independent variables for an error analysis, primarily because of the complexities of the control systems used in the two stages of the launch system.

4. In addition, the operational choice is governed by a very large number of dependent variables. Some of these are: perigee altitude, injection altitude, mean altitude over targets, minimum and maximum altitude over targets, ground track spacing, drag effects, control capability, tracking capability, range safety, target lighting conditions, redundancy of coverages, trajectory generation capability, thermal control of vehicle, recovery zone conditions, dispersions and uncertainties of parameters, booster capabilities, payload margins and reliability, auxiliary payloads, variations in parameters over vehicle life, usable lifetime, etc.

5. For optimization of a flight for the acquisition of a single target, the selection of the appropriate set of parameters is a small task: the largest number of acquisitions of a single target are achieved with the inclination equal to the latitude of the target; with perigee at the target, the best resolution is obtained; the period can be chosen to give a large number of passes over the single target, eccentricity is relatively unimportant, and the launch time can be chosen for suitable illumination of a large number of passes. Range safety, booster capability, control capability, recovery considerations, and trajectory generation times need be considered in the availability of the desired orbit; but for this simple case they can generally be worked around if time is available. The more usual operational case involves targets spread over a wide range of latitudes and longitudes, with varying priorities assigned to targets, and a desire to get good quality results on all photography attempted. The weighting factors used in selection, to date, have not been well quantified, and are often not fully documented. In the post flight analysis of results, the operational compromises taken are usually not known, and all photography is compared with the possible quality; little adjustment is made for the weighting of the photography where the quality was attempted to be maximized.

6. As an example of the qualitative thinking that must go into the planning and operation, consider for the moment, the choice of instrument cycling rates and ramp in past CORONA missions:

> The CORONA system, as flown last year, had a limited number of ramps (time varying cycling rate functions). For this reason, a good fit of IMC and overlap (tied together in camera functioning) could not be made on all targets on a single pass. In addition, exposure was tied to cycling rate because of the fixed slit. In the flight operations, compromises were necessary. The general rule used was, that if compromise was necessary, overlap was a prime requirement, over the total operation. IMC would be biased as necessary to provide overlap (positive) considering the lack of knowledge of actual orbit and actual camera operating speeds. One can forecast that the mean IMC error would not be zero, but would be somewhat greater than zero, dependent upon the nature of the estimated orbit, the nature of the particular phase of the mission, etc. The improved control system now in effect does minimize this problem, as the whole orbit can be fitted within one or two percent, IMC error, well within the ten percent overlap design value. Thus, currently, it should not be necessary to consider possible negative overlap in choosing ramp values. The mean IMC error should now approach zero.

In the overall choice of orbit, many similar compromises need be made, and the total operation considered.

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Development Division
(Special Activities)

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